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ISSUED ON THE FIRST AND FIFTEENTH OF EACH MONTH. FORMS CLOSE FIVE DAYS PREVIOUSLY. ENTERED AS SECOND-CLASS MATTER, AUGUST 3, 1916, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER ACT OF MARCH 3, 1879

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AVIATION
AND
AERONAUTICAL ENGINEERING

LADISLAS d'ORCY
ASSOCIATE EDITOR
GEORGE NEWBOLD
BUSINESS MANAGER

Vol V December 15, 1918 No 10

THOSE who are awake to the development of the times cannot but wonder at the truly remarkable course aircraft and engine design and production have followed in the United States since our participation in the conflict.

Next to the quickened sense of democracy, the richest heritage which this war has left the world is to be found in the wonderful advance made in the aircraft art and overwhelming proof of the practicability of air transportation

Although pioneers in aviation, America had been up to the time the world war began in 1914, slow to take advantage of its scientific leadership, almost entirely due to lack of governmental interest and support such as was freely extended by foreign governments to their aircraft engineers. A group of engineers and manufacturers, however, had labored to overcome this backwardness and thus, when the United States entered the war, Washington found available the nucleus of an organization which developed within eighteen months into one of the three major weapons which we placed at the disposal of humanity—weapons used by land, sea and air

When the Central Powers laid down their arms, America was fast approaching the stage where it would hold undisputed leadership in the air American built aircraft had gone through the furnace of war, and emerged victorious from the supreme test of reliability, and so had American airmen, to whose gallantry and proficiency it is justice to give due acknowledgment

At about this time the first American designed fighting aircraft were also beginning to come into their own showing performances in speed climb and manœuverability which have demonstrated conclusively that American types of aircraft today are unexcelled in the world This is a statement which no one with a knowledge of the facts will challenge We have today the *best* training machines, heavy and light bombers, observation and fighting planes, the most powerful engines and the lightest engines per horsepower

The signing of the armistice was followed by a somewhat hasty reaction, in which a desire was manifested on the part of the various authorities in Washington to curtail war production and accelerate the resumption of normal activities Insofar as the aircraft industry was concerned there occurred cancellations amounting to some $200 000 000 affecting every one of the plants which had enabled the United States to take her place among the first-rate flying nations.

While liquidating aircraft contracts, the departments concerned with aviation are going ahead with estimates for considerable expenditures during the fiscal year beginning July 1 next. Thus a budget has been prepared which requests a total of $165 000 000 for the War Department, of which $145,000 000 is for aircraft production and the development of air navigation, and $20,000 000 for the peace time personnel, while the Navy Department asks the sum of $225 000 000 for an aircraft program that will be commensurate with its enlarged sea budget The Post Office Department is thoroughly awake to the possibilities of the airplane in the mail service The Chairman of the Post Office Committee of the House has just introduced a bill asking $2,185,000 for the air mail service for the next fiscal year.

Thus Congress is to be asked for a total of $392,185,000 for the development of air navigation during the fiscal year beginning July 1, next.

But long before any part of these sums shall have become available the aircraft industry is likely to perish, for, although the Government has still many millions of dollars available for aviation purposes, it apparently fails to recognize the necessity for providing for the industry between the present, when contracts are being liquidated wholesale, and July 1 next, when the new appropriations will be available. Unless a constructive program is immediately formulated and put into effect, the engineering talent, industrial genius and financial backing of the aircraft industry will seek other fields. In fact, this process of dissolution has already begun and is proceeding at an alarming rate.

It would portend a lamentable lack of foresight if this situation were permitted to develop unchecked Although conceding that some confusion must attend the shifting of governmental machinery from war time to peace time conditions, there can be no excuse for failure to grasp the magnificent opportunity which is offered America to become supreme in the air, in the military and naval as well as in the commercial field. The war has demonstrated that the airplane is the cheapest form of military and naval weapon and that it is the best peace insurance But the hour demands quick and decisive action with respect to announcing a constructive policy, one that will maintain intact the engineering and creative ability now available for brilliant progress in aeronautics, in a word, a policy which will prevent America from sinking back into the insignificant place it held in aeronautics before the war.

Those who understand fully the peculiar position in which the American aircraft industry now finds itself declare that, unless steps are taken at once to release some of the funds which are available, so that the present critical period may be safely weathered, plants will be forced to close, their invaluable scientific and technical organizations will be scattered to the four winds

Then, when the various departments seek to develop their aircraft programs after July 1 next, they will be confronted with a depleted industry and will be forced to expend far more money, time and energy on the problem of rehabilitation than an immediate program would call for now

Here is something which challenges individual thought, not only by the statesman, scientist and manufacturer, but by the average man who, affected by the glamour which surrounds flying, has given little heed to the practical underlying facts

To retain what was first won for us by the Langleys, Wrights, Curtisses and Burgesses, to prevent any lapse in the wonderful development which has come out of our aeronautical effort in the war, demands decisive and coordinated action in cooperation with the engineering talent of the industry by all departments of the government which have made or considered tentative plans for utilizing aircraft, otherwise America will lose the place she has won in the air

The Boeing Aerodynamical Laboratory

By F. E. McKone

There is so much at stake in the construction of aircraft that expense does not bulk as large as in other lines of manufacture, which explains why there should be a decided effort to obtain the best that research can give. In this connection all of the laboratories throughout the world where the laws of aerodynamics are being investigated command the attention of the aircraft manufacturing world. One of the latest laboratories to be completed is that in Seattle on the campus of the University of Washington.

The laboratory is a gift of Mr W E Boeing, a manufacturer of airplanes in Seattle, Wash., to the University of Washington. Fig. 1 shows the building officially known as the Boeing Aerodynamical Chamber. This building, because of the war, was held to a one-story wooden structure, although the plans call for a two-story building where students may recite, and a large drawing room for student design of aircraft. The second floor is planned as a layout room, to be used jointly for dirigible and naval architecture, occupying the whole floor, a space 80 by 50 ft.

FIG. 1 THE BOEING AERONAUTICAL TESTING CHAMBER

The size of the completed section is 80 by 20 ft., with a small basement under the building. This gives a depth of 20 ft. to the chamber which contains the wind channel. The office is in the rear end of the building, extending back to the first rain spout. On the other side of the building, facing the Engineering Hall, which may be seen over the top of the aerodynamic chamber, a door for the students leads into the office and to the testing chamber. A room the same size as the office, and situated underneath the latter, is used by the students for computations. This is separated from the testing chamber by a partition largely of glass to provide light. It will be seen from this illustration that the testing chamber is abundantly lighted.

The University campus borders on both Lakes Washington and Union, which are connected to Puget Sound by locks. Over these lakes full scale testing of seaplanes is in progress the year around as the climate and other conditions are favorable to all year flying. Opportunities for collaboration between the laboratory on the University grounds and the full size testing done by the Boeing Airplane Co. seems to be abundant.

The Testing Chamber

The interior of the testing chamber is shown in Fig. 2, as seen from the doorway of the calculating room under the office. The bell shaped entrance to the channel is 10 ft. from the partition behind the camera. The office above is separated by the same style of partition so that the instructor can exercise a general supervision of all laboratory work while in the office above.

The square patches in the ceiling are sixteen in number and will carry 300 watts per outlet. This has not seemed necessary, with the exception of the six in the center of the chamber where 200 watts is carried, 100 watts have proven sufficient. The reflectors are of metal, with mirror interior set into the ceiling so that the diffusing glass is flush with the ceiling. Dr Osburn, illuminating engineer for the University of Washington, contributed largely in the solution of the lighting problem. As a result of his investigations, the work in the laboratory can be carried on at night with as little fatigue to the eyes as in the day time. Even the instruments under the channel can be read easily using only the ceiling lights. The intensity of light varies little in different sections of the room when measured at the same level from the floor. A great amount of light from the ceiling lights shines on the instruments under the channel because of glass windows in top, bottom and sides of the channel of this section. The ceiling lights are two outlets to a circuit ensuring the greatest economy in the use of the electricity, at the same time getting the light where needed. The light in the calculating room consists of two outlets of 200 watts semi indirect. The office above has the same amount of light wholly indirect. The cost of this lighting system was much lower than for many systems giving far poorer illuminating results. It is simple, clean and creates no air disturbances as the air is pushed through the room. The flush arrangement of the diffusing glass, with no dangling elements to catch dust, seemed to fit into the plan of a free-from-dust room. This is a very important feature of a wind channel testing room.

One of the main considerations in the design of the testing channel was the feature covering the possibility of continuous testing. Even in times of peace it is most economical to run a test through as quickly as possible, so there may be no congestion in the use of the channel. This seemed of special importance at the time the laboratory was planned inasmuch as the war demands on a wind channel greatly exceeded those of normal times. To ensure the successful operation of a testing channel there must be the fullest confidence of the testing foreman on each shift in his fellow foreman. Without this the whole scheme fails.

The Wind Channel

The channel proper in general design is like that of all 4 by 4 ft. square tubes, which have been successfully used at the Massachusetts Institute of Technology, Cambridge, Mass., the laboratories of the Curtiss Aeroplane and Motor Corp., Buffalo, N. Y., and the National Physical Laboratory, Teddington, England. The most notable departures consist in the use of a propeller of 9 ft. diameter, with four blades of low pitch, instead of the usual 7 ft. size. This makes the diffuser at the far end of the room larger and the tube lengthened. An inspection of the channel will show a wear-resisting and rigid construction. The channel is made of three-ply fir and is finished in dull mahogany.

The use of a 9 ft. propeller made the length of the channel and the diffusing box 53 ft. over all. The extra length is due mainly to the metal tube which conducts the air from the square section to that of the propeller. The enlargement of the tube is in two sections. The first connects to the square wooden channel and expands the air from 16 sq. ft. to a round cross section of 27.2 sq. ft. in a length of 5 ft. 6 in. In six additional feet the cross section expands to the area of a circle of 9 ft. 1 in. diameter, or 64.8 sq. ft. area.

In the mouth of the channel a nest of 256 pipes, 2½ in. in diameter and 2½ ft. long, made of Russian iron, are stacked as shown in Fig. 2. This nest is made up of sixteen sections, each made up of sixteen pipes. The pipe seams leave the inside of the pipe smooth, coming entirely outside. These seams are brought together and the pipes are soldered along these making a smooth job throughout. With these units it was possible to get good alignment. The function of these tubes is to have the air follow parallel lines at all points to the sides of the channel. The more perfectly this is accomplished, the more nearly will the condition of flying in still air be approached.

Also, in order to approach this condition, care in the design of the propeller is essential to have as uniform a rate of flow of air, both across the channel and as regards time. A low pitch propeller with a large diameter assists these conditions. The propeller is of mahogany, made up of five laminations, and is mounted on a standard S. A. E. hub, both are manufactured by Hall Scott Motor Corp., California.

The propeller drive is the usual silent chain of the Link belt design. The jack shaft to which the propeller hub is bolted runs in two ball bearings at a speed of 1000 r.p.m. The chain passes between them over a 25-tooth sprocket of ⅝-in. pitch. The bearing housings in both cases are of S. K. F. design, but only one of the bearings is an S. K. F., inasmuch as thrust had to be taken care of and for this purpose a New Departure bearing was fitted to the other S. K. F. housing. By a spring arrangement provision is made for the shaft to float along the shaft and any movement of the armature of the motor below is thus cared for without jar or vibration.

An important consideration in the design of a wind channel is the matter of being able to hold the propeller revolutions constant during a reading of the instruments at some given speed. It must be possible to vary this speed from 400 to 1200 r.p.m., so as to conduct tests at different wind velocities. If direct current is available the cost of the electrical equipment is much reduced. This was not the case at the University of Washington and it was necessary to arrange for the conversion of the alternating current, which was done by using a General Electric Co. MIC type motor generator set. This unit is shown in Fig. 3 at the far end of the room on a concrete foundation, 27 by 24 in., and raised 10 in. from the floor, it weighs 1080 lb., is 15 kw. capacity, and has a normal speed of 1800 r.p.m.

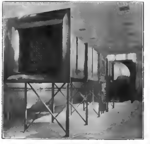


FIG. 2. THE WIND CHANNEL

The motor which drives the propeller through a silent chain is an R. F. adjustable speed motor, which was built by the General Electric Co. This motor is seen under the diffuser on a foundation 22 by 21 in., raised 12 in. from the floor. Two inches of this is the two-by-fours which act as absorbers of any vibration which may occur. This motor weighs 1445 lb., and has a normal speed of 400 to 1200 r.p.m. Its capacity is 15 hp. for non-continuous service.

The wiring from the motor to the generator set is under the concrete floor in metal conduits. Wiring from the control board to the motor is more likely to have alterations made so that this line was run in metal conduit close under the channel.

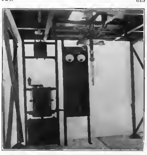


FIG. 3 PRESSURE BALANCE AND WIND CONTROL

The Instruments

The control board and balance are shown in Fig. 3, as well as the angle iron construction holding up the channel. From the metal conduit the wires are shown leading to the circuit breaker. From here the wires run concealed to the controller below and continuing to the resistance under the controller. Proper wires are carried across behind the instrument board to the various instruments. On this board are ground lamps, shown lighted. The voltage and current are registered on the instruments. The current was not large as the propeller was not on the shaft, and was being turned over. Resistance, switch and fuses constitute the remainder of the equipment on the instrument board.

The balance which records the wind pressure was constructed by engineers of the Curtiss Aeroplane and Motor Corp. and is similar to the balance used in their own laboratory. The frame holding the remainder of the balance is fastened to the underside of the channel. Between this and the plate glass is a rubber collar for sealing so that no air may enter the channel at this point due to a reduced static pressure inside caused by the propeller suction. The balance passes up through this collar and also the plate glass. On this projecting spindle the model under test is placed. In order to protect the spindle from setting up a turbulence in the channel a correctly shaped spindle guard is fastened to the glass. By means of thumb screws, the balance may be made to pivot either across or along the balance. This takes care of the drag and the lift on the model by the usual method of balancing weights. There is a disk which allows for the varying of the angle of attack and maintains the angle throughout the reading. There are weights also for getting greater sensitivity.

The installation and building cost approximately $12,000. In order to preserve alignment of this equipment, the building is adequately equipped for heating. It has been found that cement paint on the floor greatly reduces the amount of dust and dirt which often rises into the air and is pumped around the room. The windows required shades to prevent the sun from blistering the varnish on the channel.

Architects for W. E. Boeing were Messrs. Sebb and Gould, of Seattle. The aeronautical engineering was done by the writer. Calibration of the channel and the instruments have not been completed.

The Bréguet B-14 All-Metal Airplane

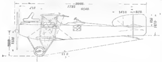
The Société des Ateliers d'Aviation Louis Bréguet, of Velizy-Villacoublay, France, are one of the oldest aircraft manufacturers in the world, the firm having been founded by M. Louis Breguet, a wealthy electrical engineer, in 1908. After having experimented for some time with a combination airplane and helicopter machine, with which he actually succeeded in leaving the ground, M. Bréguet produced in 1909 the first tractor biplane and flew it himself at the Reims aviation meeting. This machine was notable for being almost entirely built up of steel tubing, in fact, outside of the wing ribs and some fairing elements in the body, no wood was used in its construction, and the body was sheathed with aluminum.

BRÉGUET DAY-BOMBER OF THE FRENCH AIR SERVICE
(C) *Committee on Public Information*

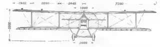
Ever since, and regardless of various difficulties experienced, M. Bréguet has maintained his faith in all-metal airplane construction, although in his latest machines aluminum alloys have to a large extent displaced steel. The airplane under review is therefore particularly interesting as affording a good example of all-metal construction, based not on recent conceptions, but derived from methodical investigations extending over a period of nearly ten years.

The Bréguet B-14 airplane is a two-seater day-bomber, and is fitted with a 12-cyl., 300 hp. Renault engine, a more recent model, the B-17, carries a 400 hp. Renault. Both are tractor biplanes.

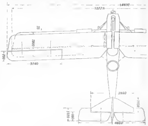
Wings—The wings have a negative stagger of 0.21 m. and a sweepback of 1.75 deg., both wings are "washed out," the incidence of the upper decreasing from 4.5 deg., at the roots, to 2.0 deg., at the tips, while the incidence of the lower wings decreases from 3 deg. to 2 deg. The upper wings have a span of 14.40 m., and a chord of 2.00 m., the lower wings, a span of 13.77 m., and a chord of 1.90 m. The chord is uniform for each wing throughout its entire length. The upper wings have a dihedral of 1.75 deg., the lower ones are straight.



SIDE ELEVATION

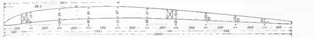


FRONT ELEVATION



PLAN

Wing Spars—The spars of both wings are drawn duralumin[*] tubes of rectangular section, 65.6 by 34.6 mm. The wall thickness of the spars is 2.6 mm. at the center section, and 1.6 mm. at all other points. The rear spar tapers down toward the tips to the thickness of the lateral wing edge, which consists of 6 mm. ash strips reinforced with 3 mm. three-ply wood. At the points where the interplane strut sockets occur, the spars are strengthened by a plugging of ash, of I-section, and by welded sheet steel sleeves, which are held in place by tubular steel rivets, and serve as a base to the sockets.



THE BRÉGUET WING SECTION

The upper front spar is partly plugged at the center section with a strip of pine, 10 mm. thick, which is secured to one side of the tube by means of small brass screws.

Internal Wing Bracing—Duralumin tubes of 27/30 mm. diameter are used as compression struts at the interplane strut joints, except at the inner joints of the lower wings, where duralumin box ribs are used. Three more box ribs occur in each half-wing, and serve as spacing members. The internal wing truss consists of single steel wire varying in diameter from 3 to 1 mm.

SECTIONAL VIEW OF LOWER WING WITH EQUALIZERS

Ribs—The ribs are loose-fit on the spars, and are set parallel with the longitudinal axis of the machine. They are not, however, perpendicular to the wing spars, but form with the latter an angle corresponding to the sweep-back because the spars are set parallel with the leading edge. The ribs are interconnected by means of three-ply planking, reaching on the upper side from the leading edge to the front spar, and by two parallel fabric straps, alternately passing above and below the ribs.

CROSS SECTIONS OF WING SPAR

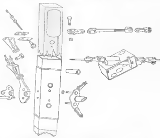
The main ribs are spaced 0.40 m. apart, and light false ribs occur between them at both leading and trailing edges. These false ribs are birch strips of 4 mm. width, while the main ribs are 16 mm. wide. The webs of the main ribs are of composite wood, consisting of a central layer of 3 mm. three-ply and two external layers of birch, the flanges are 6 mm. thick.

The wings are surfaced with a fabric of yellowish color, this is sewn onto the ribs, and strengthened with wooden strips where it is exposed to the slip stream. Eyelets are provided for the drainage of moisture and equalization of air pressure.

Ailerons and Equalizers—Only the upper wings are fitted with ailerons, and these are hinged to the rear spar. The ailerons have a span of 3.74 m. and a chord of 0.82 m.; they are balanced.

On the lower wing the portion situated behind the rear spar is hinged to the latter along its entire length. The hinges are fitted to the upper face of the wing spar and to the top surface of the movable portion, and the latter is maintained at a given angle by the pull of twelve rubber cords, which are fixed to the underside of the ribs. The tension of the rubber cords can be adjusted (on the ground) by means of set screws. The object of this arrangement is, of course, to provide in flight for the automatic adjustment of the wing camber to the loading of the airplane.

These "equalizers"—as the movable wing portions may be called for want of a better name—are by the way but a modification of the old Bréguet system of automatic camber control by means of a flexible trailing edge. The pre-war Bréguet airplanes had single wing spars, with a single row of interplane struts, and the incidence of the wings was entirely determined by the tension of springs carried inside the wings. While the speed and weight carrying performance of these machines was quite remarkable—ten airplane passengers having been carried for the first time on a Bréguet—the action of the automatic wing control was not always trustworthy and actually caused several fatal accidents.



LOWER SPAR FITTINGS FOR CABLE ATTACHMENT

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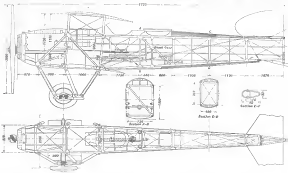
[*] The term duralumin is here used for sake of convenience to express the high tensile aluminum alloy employed in the Breguet, although this metal is not properly speaking duralumin.

In view of this fact it is highly significant that this system should have survived in a modified form on the model B 14, which is one of the most successful day-bombers of the French Air Service, and apparently shows that the value of the equalizers is more than theoretical, and their mechanism now entirely dependable.



Sectional Side Elevation and Plan

The hinges which connect ailerons and equalizers to the wings are sheet steel stampings, which are held in place by through-bolts. The spars are not plugged at these points.

Interplane Struts—The interplane struts are duralumin tubes of streamline cross section, and fit into duralumin sockets. The inner pairs of struts are internally strengthened by a cross-member of channel steel, which is riveted to the sides of the struts.

The duralumin used in the interplane struts has a tensile strength of 40 kg. per sq. mm., and an elongation of 18 per cent.

Flying and Landing Wires—The flying wires are 4.5 mm. cables, double, with wooden fillers in between. The landing and incidence wires are 2.5 mm. cables, also carried in double, and similarly connected with one another. The wiring plates are sheet steel stampings.

Body—The body is almost entirely built up of duralumin tubes, which are joined through riveting by means of welded steel tube sleeves, and are spanned with wire. Only at specially stressed points, in the front part of the body, have steel tubes been used. The upper and lower sides of the body are rounded off by means of fairings. The covering is canvas, except around the engine, where aluminum plating is used.

The engine bed consists of duralumin bearers of U-section which are supported by struts of the same metal. All joints are riveted.

The tail planes are built up of welded steel tubing, and are surfaced with canvas. One may note, as a departure from what would seem to be standard French practice, that the elevator is balanced at the tips, somewhat in the fashion of the Gotha, although the rudder is non-balanced.

Undercarriage—The undercarriage is of very sturdy construction. It consists essentially of three pairs of duralumin struts of streamline section, which are reinforced internally by a channel steel member, like the inner interplane struts, and are joined by two horizontal steel tubes. The joints are sheet steel sleeves, and are riveted to the struts. The axle, rubber sprung to the horizontal struts, is a 55 mm. steel tube and rests in a streamline guide of sheet steel. The streamlining is cut out in the middle to improve the sight downward.

The tail skid is of ash, duralumin-shod, and provided at its lower end with leaf springs of steel. It is pivoted to the sternpost, and rubber sprung.

Power Plant—The power plant consists of a V-type, 12-cyl. Renault engine, water-cooled, which develops 300 hp. at 1,500-1,600 r.p.m. This engine is practically identical with the 200 hp. model, the higher power resulting from the use of aluminum pistons and increased engine speed. The exhaust is led over the upper wing by means of a streamline collector. The engine drives a two bladed airscrew direct. The cooling system consists of an aluminum radiator, fitted in the nose of the machine, which is divided in the middle; each row of cylinders thus has its individual cooling system with a separate water pump.

Gasoline System—Two gravity tanks, of 130 liters capacity each, are mounted behind the engine, flush with the upper face of the body. As their underside lies only a little above the carburetors, an auxiliary tank of 5.6 liters capacity is provided in front of each carburetor. These tanks fill themselves by gravity from the main tanks when the airplane is in horizontal or gliding flight, while in climbing the carburetors are supplied from the auxiliary tanks. Check valves fitted to the piping prevent the gasoline from flowing back into the main tanks.

The fuel level in the main tanks is indicated electrically by pressing a contact; for this purpose a hard rubber tube is mounted in each tank inside a tube, and wound with a resistance wire of 0.4 mm. thickness, above which a cork float with contact moves. The fuel supply is sufficient for a flight of about 2½ hours' duration. An oil tank of 18 liters capacity is mounted on the right hand side of the engine.

Equipment—The B-14 is equipped with dual control, the observer's control set can be disconnected at will. Instruments are, however, fitted to the pilot's cockpit only (excepting throttle and switch, which are duplicates), and comprise: tachometer, watch, altimeter, two radiator thermometers, push buttons and indicator arrangement of the gasoline levels, and compass, all of which are mounted on the instrument board protected by a sheet of Triplex glass. To the right of the pilot are mounted: radiator-shutter control, starting magneto, gasoline spray pump for starting, gasoline and oil stop cocks, and switches for night lighting and wireless. To the left of the pilot are: throttle and spark levers, air supply control, magneto switch, and gasoline stop cock.

A fixed machine gun, for the pilot, is mounted outside of the body, to the left, and is operated by an interrupter gear from the camshaft.

The observer is seated in the rear cockpit on a hinged seat which enables him, when not serving the twin machine guns mounted on a revolving ring, to crouch low in the body for the purpose of observing the ground below through the Cellon windows which are fitted to the bottom and sides of his cockpit. The bomb release and wireless control levers are mounted to the right.

The bomb magazine is located in the middle of the lower wings and contains sixteen small bombs, hung in two rows of eight, parallel to the leading edge. The bombs are released in pairs, that is, two lying in the same fore-and-aft axis at a time, by the action of two camshafts mounted in front of the forward wing spar. The camshafts are connected with one another by a pulley and rubber band transmission acting on a transverse shaft, which is operated from the release control, in the observer's cockpit, by means of chain and sprocket transmission fitted with a locking lever.

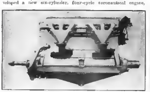
On some of these airplanes provision is made for the carrying of two large bombs inside the pilot's cockpit, but even then the release device is controlled by the observer, the bombs' sight being in each case mounted in the rear cockpit.

Weight Items—The weight of the B-14, empty, is 1,215 kg. The normal useful load is 514 kg., and the maximum useful load, 614 kg., to which must be added the weight of the fuel, 216 kg. Fully loaded, the machine thus weighs 1,945 and 2,045 kg., respectively, which gives, in the former case, a wing loading of about 40 kg. per sq. m., and a power loading of 6.5 kg. per hp.

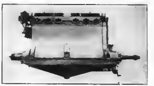
The Aeromarine, Type L, Aeronautical Engine

By Charles F. Willard

With the object of providing a power plant suitable for training and sporting machines, and appreciating that simplicity, accessibility and durability without undue weight are essential, the Aeromarine Plane and Motor Co. has developed a new six-cylinder, four-cycle aeronautical engine, known as Type L. This engine, which is water cooled and of the valve in the head type, has cylinders of 4¼ in. bore and a stroke of 6½ in. The weight of the engine is 375 lb., and when equipped with electric starter and generator it weighs 405 lb. The rated horsepower is 130 at 1625 r.p.m.



Aeromarine, Type L, Inlet Side



Aeronautical Engine, Exhaust Side

Crank Case and Cylinders

The main portion of the crankcase and cylinder jackets are integrally cast of aluminum alloy. This type of design eliminates a multitude of bolts, screws and fittings, and as well gives an extremely rigid structure. The cylinder sleeves are alloy steel forgings, machined all over, to give a uniform wall thickness. After machining, the sleeves are heat treated, and the working surfaces ground. The outside of these sleeves are in direct contact with the cooling water over their entire surface. The cylinder head gasket, of copper and asbestos, makes a tight joint against the top flange of each cylinder sleeve. The water joint at the bottom of each sleeve is by individual cork gasket, which allows freedom for expansion, and at the same time makes a perfectly satisfactory joint.

Cylinder Head and Valve Gear

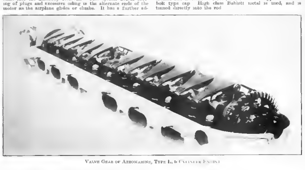
The cylinder head and valve gear form a complete self-contained unit, which can be removed from the engine in a few minutes, allowing inspection of the valves combustion chamber and making it possible to remove the carbon or grind the valves within the very shortest possible time. The removing and replacement of this head may be accomplished without re-timing the motor, due to a special arrangement of the splined shaft which drives the camshaft gear. The head is of aluminum alloy with gray iron valve seats cast in position.

The combustion chambers are machined. The water cooling of the spark plugs, exhaust valve guides and valve seats is exceptionally complete. The cams and rollers are housed in, precluding possibility of oil reaching the combustion chambers through valve stem guides. There are four valves for each cylinder, two exhaust and two inlet. A special design of valve gear, embodying flat multiple leaf valve springs, effects a great reduction in length and weight of valves and valve levers, and also reduces the over-all height of the motor. Each valve spring actuates two valves.

By a special design of the valve adjusting screw, a rolling contact is obtained between it and the end of the valve, thus eliminating the possibility of any side motion being transmitted from the valve levers to the valve stem. There is an oil return passage from each end of the cylinder head to the crank sump. The whole valve gear is enclosed in a quickly detachable aluminum cover, so that when the motor is in operation there are no moving parts visible and the possibility of a pilot being annoyed by oil from the valve gear is entirely eliminated. The camshaft is hollow with integral cams and is driven by bevel gears and vertical shaft from the power delivery end of the motor.

Oil System

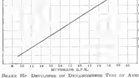
This engine is of the dry sump type, a dual pump being used to deliver the oil pressure to the working parts and to draw the surplus oil from under the sump, discharging the same into the auxiliary reservoir. This system avoids sooting of plugs and excessive oiling in the alternate ends of the motor as the airplane glides or climbs. It has a further advantage in that the oil in its passage to and from the auxiliary tank is cooled. All bearing surfaces in the engine, except valve stem guides, lubricate by pressure fed oil.



Valve Gear of Aeromarine, Type L, 6 Cylinder Engine

Crankshaft

The crankshaft is an alloy steel drop forging, heat treated, machined all over and dynamically balanced. It is of three main bearing type with additional propeller bearing. The bearings are of liberal size, the crank pins being 2½ in. in diameter by 2⅝ in. in length.



Brake Hp Developed on Dynamometer Test of Aeromarine, Type L, Aeronautical Engine

Pistons

The pistons are of aluminum alloy, ribbed under head, and are fitted with two sealing rings above piston pin and an oil scraper ring below. The piston pin oscillates directly in piston pin bosses.

Connecting Rods

The connecting rods are alloy steel drop forgings, heat treated and machined all over, are of I-beam type with four-bolt type cap. High class Babbitt metal is used, and is tinned directly into the rod.

Ignition

The ignition is by double Delco instruments driven directly from the end of the cam shaft. There are two spark plugs in each cylinder.

Starter

A Bijour electric motor starter is arranged to drive the motor through the rear end of the crankshaft, by means of a special automatic engagement and planetary reducing gear which has a ratio of 56 to 1.

Generator

The Bijour generator is driven from the rear end of the camshaft. The motor and generator are built into the design in a neat and efficient manner.

Carburetor

Two carburetors are used to supply the six cylinders and are now arranged on the side of the engine above the beds as shown in the accompanying photographs. It is considered possible that a dual carburetor may be placed back of and behind and below the motor with a dual feed pipe in the event that it is desirous to use a gravity feed.

The Power Curve

The power curve is shown in the accompanying diagram. This engine has been run to speeds in excess of 2500 r.p.m. for some considerable period of time, and even at this excessive speed the peak of the power curve had not been reached.

Fuel Consumption

Tests extending over a period of more than 100 hours indicate that the fuel consumption of this engine is, approximately, 495 lb. per hp.

Properties of Airplane Fabrics*

By E. Dean Walen

The design of heavier-than-air machines during their early stages of development was arrived at by cut-and-try methods. The wings of such machines were covered with plain cotton fabric, much the same as an ordinary sheeting material, coated with a beeswax compound or some form of glue. The wing surfaces were then rubbed and polished to present a surface having a comparatively low skin friction. Such a covering was not very strong and sagged very materially when subjected to pressure and when exposed to weather.

As the application of science produced planes which were capable of much higher speeds, smaller wing surfaces, and a consequently increased loading per square foot of wing surface, it became necessary to cover them with a material having a high strength and a low weight.

It was generally known that flax spun into yarns and subsequently woven into fabrics produced a very tough material having little stretch and the property of withstanding shocks with very little permanent set. Accordingly, unbleached linen fabric was used to cover the wings of planes and found to be very satisfactory. The structure of the linen fabric is that of an ordinary fine linen sheeting. No attempts had been made to study the requirements of the covering material or to design a fabric meeting those requirements which might possibly be lighter and more resistant than the linen fabrics.

When it became evident that the available supply of linen would not suffice the demands of the military programs of the countries at war, and it became necessary to find materials which could be used in place of the satisfactory linen.

As early as January, 1916, the Bureau of Standards started investigating the possibilities of substituting cotton for linen airplane fabrics, and found that the general consensus of opinion among airplane manufacturers and investigators here and abroad was that the use of cotton fabric for wing coverings was out of the question, as many experiments had already been made to substantiate these opinions. However, we were certain that not all the possibilities of structure of fabric had been considered, and we began an investigation to study the stresses in a fabric on a plane and to thoroughly determine by actual measurement the properties of the linen fabric and to incorporate the desirable properties of the linen in a cotton fabric suited for the purpose.

The difficulties experienced in the experiments on cotton fabrics previous to the time of our investigations were: (*a*) low strength per unit of weight, (*b*) low tearing resistance, (*c*) little shrinkage upon application of dope, (*d*) little tendency to retain what little shrinkage they had after doping.

It was not until March 18, 1917, that we were in a position to issue instructions covering the construction of cotton fabrics for the experimental fabrics, which proved to be quite successful. These instructions were sent to the various fine-goods cotton mills and were supplemented by visits of our textile experts to the mills. At the mills our textile men sat down with the practical men and evolved the present cotton airplane fabrics. At this point I wish to mention the name of Mr. Richartson, agent of the Ponemah Mills, as he did much to make cotton fabrics a success.

The first fabrics of this series were received at the Bureau on or about the first of April, 1917, and as the series progressed we suggested changes, and during the early part of May, 1917, a fabric had successfully passed our laboratory standards. The next important problem was to determine the actual performance of these fabrics. To this end samples were placed on Army planes at Langley Field and Navy planes at Pensacola during August, 1917. Similar fabrics were later sent by the Signal Corps to the Canadian Aeroplane Co., of Toronto, Can., and they were placed on planes the middle of October, 1917.

The results of the service tests demonstrated that the fabrics were satisfactory and that service results could be reliably predicted in the laboratory. In view of this we felt justified in modifying the structure of these fabrics, and in cooperation with R. L. Kingston, then with the Curtiss Aeroplane Co., and with A. R. Pierce, of the Pierce Manufacturing Co., the present Grade A cotton fabric was evolved.

It was not until August that the military authorities were becoming concerned with the scarcity of linen, and on or about August 23 the Joint Army and Navy Aircraft Board called the Bureau into a conference regarding cotton fabrics for airplanes, and we were able to say with a great degree of certainty that we had a fabric ready for their needs.

On Aug. 24, 1917, a conference held between the military authorities and representatives of the Bureau resulted in the Signal Corps Equipment Division ordering that the Bureau of Standards supply the necessary specifications covering the purchase of 500,000 yd. of airplane cotton fabric. The specifications were transmitted by the Bureau of Standards on Sept. 5, 1917, covering the fabrics now known as Grade A and Grade B as used by the Signal Corps and Navy. A few days later the Bureau supplied the necessary information regarding the apparatus and methods of testing and inspection.

Recently the standard fabrics were submitted to the English airplane authorities, and their comments were to the effect that the results of their tests were astonishingly successful. Since that time the English have adopted the standard Grade A fabric.

At the time we were making our field tests at Langley, the Italian Aviation Mission was there. One of their planes was covered with a cotton fabric which they had used successfully on the battle front, and the members of that Mission offered the opinion that our fabrics were better than their own successful fabric. It is a peculiar thing that upon analysis this fabric differed but slightly from our own as far as thread count and yarn number were concerned.

Method of Covering Airplane Wings

The frame of an airplane wing is covered with a fabric according to one of the following methods. The fabric is sewed into a piece which is wide enough to cover, and is folded completely over and under, the wing frame. It is then tacked on the three open sides after being stretched just enough to take out the wrinkles. The raw edges of the fabric are then sewed together and the tacks removed.

The other method consists in making of a pocket of fabric and slipping it over the frame. The open end is then tacked and sewed the same as in the previous case. The system of threads in the fabric may have the following two relations to the major and minor axes of the wing: The warp running from the "leading in" edge to the "trailing" edge, or parallel to the short or minor axis of the wing, or it may be put on such that the warp is at 45 deg. to the axis of the wing. The fabric is laced to the wing ribs at intervals of about six inches. After the fabric is on the frame, it is treated by means of a brush with a solution of cellulose acetate or nitrate with suitable stabilizers, etc., which is termed "dope." The dope has the property of producing a tight drumhead-like wing covering, which is often attributed to the shrinking of the fabric. It also serves to fill in the interstices of the fabric, making a surface which has a coefficient of friction to air approximately equal to that of plate glass. The doped wing fabric may be considered as a rectangular membrane fixed at two sides and supported on the other two sides by the ribs of the frame, and that the wing is composed of many of these sections.

Determinations of the Properties of Undoped Fabrics

Moisture. The fact that all fibers, either animal or vegetable, absorb moisture in varying amounts is very well known. The effect of the moisture absorbed is little considered other than it affects the weight determinations.

For the purposes of this paper it is sufficient to know that the physical properties change in value with a change in the moisture content of the specimen, and that the changes of the properties of the various vegetable fibers are very much of the same order.

In view of this it is necessary to either fix the moisture content of the materials being tested, or to expose them to a constant and known atmosphere. The ability of a material to absorb moisture is a distinct property of that material, and any

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*Presented at the Annual Meeting, New York, December, 1918, of The American Society of Mechanical Engineers.

method which fixes the moisture content does not allow of the accurate determination of the properties.

The moisture content of the test specimens is that absorbed by the material when exposed to an atmosphere of 65 per cent relative humidity at 21 deg. Cent. until the moisture of the sample is in equilibrium with that of the atmosphere. This condition of atmosphere will be considered in this paper as a standard for the accurate determinations of the properties of textile materials. The amount of moisture is found by drying the sample to a constant weight in a ventilated drying oven maintained at a temperature of 110 deg. cent., and expressing the difference in weight from the conditioned weight in terms of the bone-dry weight. This is commonly termed "regain."

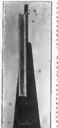

FIG 1. INSTRUMENT FOR MEASURING THE LENGTH OF YARN

Weight. Pieces of 4 sq. in. area cut from various parts of the sample and weighed after exposure to the standard atmosphere, and the results expressed in terms of weight per unit of area. The commercial method of determining the weight per unit of area involves the measuring and weighing of an entire roll. A casual consideration of the two methods would lead to the conclusion that the latter procedure would give the more satisfactory result. However, the tension during measuring is not a constant or known amount. The variation in tension introduces an error, and the weights determined by this method usually run lighter than those determined from the small samples.

Length of Yarn. The length of a yarn is considered to be that length when the yarn is straight and under no tension. The yarn is stressed in tension by equal increments of load and the stretch readings are taken at any particular load when the increments of elongation per unit of these are small. The stretch is plotted against the load. It has been found that after the fibers and the yarn have adjusted themselves, the load-stretch curve follows a straight line. The straight-line portion of the curve is extended to intersect the zero-load coordinate, and this length taken to be the length of the yarn when straight and under no tension. The apparatus is shown in Fig. 1. The yarn *A* is clamped at one end in the clamp *B*. The other end supports the weight pan *C*. The yarn is prevented from untwisting by the cross-arm *D*. The clip *G* is an index mark to read the changes in length on the scale *F*.

Crimp. The crimp of a yarn is the increased length of the yarn taken from the fabric over the length of the fabric. The difference is caused by the interlacings of the yarns. This length of the yarn removed from the fabric is determined in the manner outlined above.

Yarn Count. The yarn count is a term used to designate the size of the yarn and is expressed in terms of length per unit of weight. For instance, a No. 1 cotton yarn has 840 yd. to 1 lb. It may be considered as a very approximate index to the diameter of the yarn.

Thread Count. The thread count is the number of yarns per inch of width of the fabric, and its determination needs no discussion.

Twist of the Yarns. It is determined by counting the turns necessary to untwist the yarn, and the result is expressed in terms of twist per unit of length of the yarn before untwisting.

Tensibility Properties. The tensibility properties of a textile material may be defined as the behavior of the material when subjected to tensile stresses acting parallel to and at the center plane or line of the material. These may be divided into the following: (a) load-stretch relations, (b) tensile strength, (c) restitution and hysteresis.

The tensibility properties are determined in a testing machine of the inclination-balance type arranged to plot autographically the stretch against the load. A diagrammatic sketch of the apparatus is shown in Fig. 2. The inclination balance is represented by the pendulum arm A, and the sector arm A_1, which are rigidly connected and pivoted at the point *B*. The principle is one of balanced moments and its theory needs no discussion. The load applied at *D* is read on the scale *C*. The fabric clamp *E*, which may be termed a pulling clamp, is operated up or down at will by hydraulic pressure acting on the bottom or the top of the piston *G* confined in the cylinder *F*. The motion of the balance arm revolves the drum *K* by means of the thin, narrow brass ribbon *N*. The motion of the pulling clamp moves the pen *L* along the vertical axis of the drum by the ribbon *M* and the magnifying pulley *H*. The pen is arranged to make a dot every second.

Thin, flat ribbons of metal are used to reduce to a minimum the bending constraint and the friction of the motion-transmitting parts. The drum is set up in cone ball bearings, and by reason of this, together with its lightness and frictionless pen, the error in the reading of the weight is reduced to a negligible quantity. The pen-moving device need not be so delicately designed, as there is available ample power to operate, and the forces necessary to operate it have no effect on the readings, only in so far as they may produce hysteresis and backlash effects in the system.

The ribbon *N* is attached to the arm A_1 at a considerable distance from the pivot point *B* and the arm itself is operated through a very small angle. These simplify the spacing of the load coördinates on the chart, as they are equidistant along a horizontal line which is cut by the arm A_1. It is obvious that there must be a correction made for the motion of the clamp *D*. This correction is made by placing a comparatively rigid body such as a piece of steel in the clamps of the testing machine and moving down the lower clamp. The pen then traces the correction. During this operation the weight coordinates are marked off on the chart.

To test the apparatus for backlash and hysteresis the direction of the piston is reversed and the pen allowed to trace the motion of the top clamp. If there is no backlash, the two lines, up and down, will coincide with each other. The effect of backlash and hysteresis in the recording apparatus is very important in the determination of the restitution and hysteresis properties of the material being tested. It was found that the apparatus used was practically free from such effects. The calibration of the chart for stretch is made by allowing the top clamp *D* to remain stationary and moving the clamp *E* a definite distance, noting the motion of the pen. This type of testing apparatus gives fairly accurate results if operated at slow speeds, as the inertia effects of the pendulum arm are very pronounced at the higher speeds of operation.

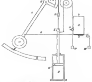

FIG 2. INCLINATION-BALANCE MACHINE FOR TESTING TENSIBILITY PROPERTIES OF TEXTILE MATERIALS

The tensibility properties are determined in the following manner, which, it will be noticed, is a deviation from the usual method. Samples of fabric are cut 3 cm. wide by 25 cm. long. These are raveled to 2.5 cm. wide and allowed to condition. They are then placed in the clamps of the testing machine with 20 cm. between clamps and stressed by reason of their being stretched at the rate of 13 cm. per min.

The inclination-balance type of testing machine is calibrated under static conditions and operated when dynamics introduce a considerable error. Obviously the inertia effect of the pendulum arm varies with the type of the material being tested. It is necessary in investigational work to correct for this error, or to operate the machine at such a slow speed that the errors arising will be negligible.

The tensile strength and load-stretch relations are taken directly from the chart. The hysteresis and restitution properties are determined by stressing the fabric specimen to a certain load, and relieving the stress in the same manner as applying it. This may be repeated a number of times and the results taken as an index of the fatigue properties of the material.

Tearing Resistance, Tensibility Method. For this particular purpose the tearing resistance is determined in the following manner, which is a slight modification of the English method.

Specimens 25 cm. wide and 36 cm. long are clamped in the testing machine with 30 cm. between clamps. Slits are cut at the center and perpendicular to the line of pull, and the fabric is then stressed at the rate of 13 cm. per min. and the maximum load transmitted recorded. The length of the slit is plotted against the load recorded.

The maximum length of slit which may be used with this size of sample is determined by the proximity of the zone of stress about the tearing point to the edge of the sample. The area of this zone is easily determined by drawing a series of lines parallel and perpendicular to the line of pull. These lines will be distorted in the zone of stress.

Resistance to Uniformly Distributed Pressure. The material is clamped over a rectangular container and subjected to air pressure. The apparatus is shown diagrammatically in Fig. 3. The deflection of the center point of the fabric is plotted against the unit pressure under the fabric by means of an ordinary steam indicator. The shape of the deflected surface is determined by measuring the vertical displacement of a series of rods placed at various points over the surface and free to move only in the vertical plane.

The rate of flow of air into the chamber under the fabric is very slow and is regulated by passing the air which is under a pressure of 10 kg. per sq. cm. through 110 cm. of 1-mm. tubing. A sheet of rubber dam is placed under the fabric to prevent air leakage. Considering these precautions, it is reasonable to assume that there is a very uniform distribution of pressure under the fabric. As there is practically a zero rate of flow of air into the indicator, it is reasonable to assume that there is no pressure drop in the connecting line.

In the surface formed by plotting the load-stretch and time relations of a fabric, there is a region where a change in the rate of load application produces only a slight change in the tensibility properties of the material. The rate of load application in this apparatus is adjusted by the definition of the pressure and dimensions of the capillary tube in such a manner that the variations in the load applications produce only a very slight difference in the recorded tensibility properties of the material.

Bursting-Tear Test. The procedure is similar to that followed in the determination of the resistance to uniformly distributed pressure, excepting that slits are cut in the fabric at various points and the pressure necessary to start the tear is recorded together with the deflection at the time of tear.

Determinations of Properties of Doped Fabrics

Preparation of Samples. The fabrics were stretched and tacked on frames under a tension of 80 gr. per cm. of width and doped in a room maintained at approximately 65 per cent relative humidity at 21 deg. cent. The frames were 30 cm. by 30 cm. (inside dimensions) for the preparation of specimens for the determination of tensibility properties and 18 cm. by 61 cm. for the determination of resistance to pressure. The properties of doped fabrics were determined in the same manner as those of the undoped fabric, with the exception that the tensibility specimens were cut to 2.5 cm. width parallel to the line of threads.

Properties of Dope Films. Films of dope were made by painting the dope on glass plates and the films were subsequently peeled off and determinations made of tensibility and resistance to pressure.

Exposure Tests. The fabrics after tacking on frames and doping were placed on the roof and determinations made periodically of their physical properties.

Value of Tests

The determinations of weight, yarn size, crimp, thread count and twist are made primarily to explain difference in properties, and more particularly to interpret properties in terms which readily adapt themselves to manufacturers' conditions. The effect of these values on properties will be indicated to give the reader a general conception of these effects.

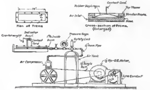

FIG 3. APPARATUS FOR TESTING BURSTING STRENGTH OF CLOTH UNDER UNIFORMLY DISTRIBUTED PRESSURE

The question of identification of fiber has not been discussed, but the effect of the different grades of fibers is noticeable when passing from one distinct staple to another. Up to the present time there have been no satisfactory methods of grading cotton other than those which depend almost entirely upon the judgment of the particular person. The choice of fiber should be left, within reasonable limits, to the manufacturer, for the manufacture of textiles to have definite properties is not a mathematically calculable process, and the laboratory can only hope to determine and indicate in a general way the effect of the many variables.

The relations between yarn number, twist, threads per inch, weight, and weave are apparently those which explain the differences in the physical properties of the several fabrics, and further serve as the most valuable manner of designation of the fabrics.

The ability of a fabric to "take the dope" is influenced almost entirely by the relations between yarn number, twist, threads per inch, weight and weave, and they are practically the only measure of such a property. The functions of the dope are to produce a reasonably tight covering, to protect the fibers from the influence of the atmospheric conditions and to produce a windtight surface. In order to perform these functions most advantageously it is necessary that one or two coats of dope penetrate the fabric enough to thoroughly protect the fibers and to serve as a necessary bond for the subsequent coats, which should be more of the nature of a surface coating. It has been thought that a yarn made absorbent by chemical treatment is more desirable, but when it is considered that such an extreme penetration of the dope will produce a brittle fabric, the value of such a treatment is practically nothing.

Provided a yarn may be made which has little hysteresis effect, it is only necessary that a thin film of dope surround the yarn. This condition is attained only at the expense of overtwisting, and its object is therefore defeated by a subsequent loss of strength of the fabric. From this it is readily seen that the dope serves a secondary purpose of supplying an additional bond between the fibers. The most advantageous condition of dope penetration into the yarn is obtained by twist regulation.

Crimp. The crimp of the yarn is the largest determining factor of the load-stretch relations of a fabric, particularly at the lower loads or under conditions of normal flight. This will be discussed under tensibility properties.

Curtiss

"THE OPEN BOOK"

Curtiss Achievements — The Great War

1—The design and construction of the fastest fighting airplane ever de Official Government records credit this triplane, which was built for the U Navy, known as model 18-T, with 160 miles per hour, carrying full milita load, pilot and passenger This is 15 miles per hour faster than any ever claimed for an airplane, a truly epoch-making achievement, made by the development of our new model K motor

2—The design and construction for the Navy of the largest flying boats in world, colossal crafts capable of carrying five tons useful load It was of these boats that recently carried fifty passengers

3—The design and construction for the U S. Navy of the fastest and most cient Seaplane in service anywhere. This craft, which is known as the Cur model H-A, with Liberty motor, made an official speed of 126 miles per ho with full military load, armament, ammunition pilot and passenger

—The development and construction of a 12 cylinder, 400 H P motor of an entirely new and much lighter type, known as the Curtiss model K-12. These motors have undergone exhaustive tests and are already in production

—The development and construction of the Curtiss model K-6, a new and much lighter 6 cylinder motor This engine develops 160 H P and possesses greatest endurance and reliability

—The development and construction on a large scale of the Curtiss OXX motors and the J-N-4 training planes, which were used almost exclusively by the United States and Canada and largely in England for the training of American and British aviators The training of over seven-tenths of the original land and marine flying pilots most of whom entered the service and formed the nucleus of the United States Aerial Training Forces.

The Curtiss Engineering Corporation is today the center of ment. Its activities, instead of being decreased, will be increased by the coming of peace. Glenn H Curtiss and his engineers have been busy in research laboratories, wind tunnels and shops in perfecting designs and carrying forward the production of suitable commercial types Aircra esigned for sportsman's use, mail carrying and other peace-time purposes are already available, and are as superior in design, workmanship and per Curtiss military planes have proved themselves to be.

CURTISS ENGINEERING CO TION, GARDEN CITY, L. I.

Tensibility Properties The value of tensile strength as a measure of the quality of an ordinary textile material has long been realized, and it was largely the fact that this value was solely considered, which misled investigators of cotton airplane fabrics

An airplane wing covering, for purposes of this discussion, may be considered as a flat, rectangular sheet supported on four sides and subjected to pressure which may be considered as uniformly distributed over an area defined by the width of the rib spacing in one direction and relatively small distance in the other direction. The stress in the material of the section being considered is a function of the reciprocal of the radius of curvature plus a factor involving what is usually termed as an axial tension load. The curvature at any given pressure is determined by the load-stretch relations of the material, and, although the load-stretch diagram does not consider the effect of axial loading, it does serve as a very valuable index to relative factors of safety of the various materials. The wing covering must be airtight in order that the pressure may not build up on one fabric alone and that flight efficiencies may not be lowered. The material will remain windtight so long as the dope film is not ruptured or deteriorated

The life of a fabric may be considered to be dependent upon the life of the dope The dope may be caused to become deteriorated rather by repeatedly exceeding its elastic limit or by exposing it to deteriorating rays of light. The latter condition may be reduced to a minimum by coating the material with pigmented varnish or dope which is opaque to the deteriorating portion of the spectrum. (This development may be attributed to an English investigator)

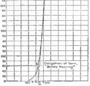

FIG 5 CRIMP OF AN UNWOVEN YARN OF COARSE AND MULTIPLE STRUCTURE

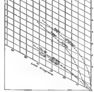

FIG. 6. LOAD-STRETCH RELATIONS OF STANDARD ENGLISH GRADE A AIRPLANE LINEN

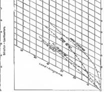

FIG 7. LOAD-STRETCH RELATIONS OF STANDARD A GRADE COTTON FABRIC

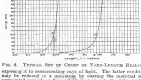

FIG. 4. TYPICAL SET OF CRIMP OR YARN-LENGTH READINGS

The shape of the tensibility curves of the doped fabric serves as a valuable index as to whether the elastic limit of the dope will become exceeded under conditions of flight.

The ability of a fabric to shrink depends largely upon its load-stretch relations. The term shrinkage has been applied to refer to fabric tautness and leads to confusion as to the nature of the tightening It has been observed that the fabrics having the least stretch at the low loads are tightest after doping, and that a plain weave fabric is tighter than a fabric woven with fewer intersections and having less stretch The fabric tautness is dependent largely upon the support which the fabric lends to the dope and the completeness with which the dope binds the yarns together in their crimped condition, and is dependent only slightly on film shrinkage.

The necessity of fabric tautness is believed to be largely dependent upon the psychology of the flyer, but, with the present dopes, fabric tightness is almost synonymous with life of the dope or fabric

It is believed that the fatigue properties of a fabric may be related rather definitely to the shape and area of the hysteresis loop Although this phase of the investigation is not entirely complete, the area of the hysteresis loop has been used to predict the fatigue properties of the materials with a large degree of success.

The relative recoverable stretch of an airplane wing covering is quite readily indicated from an examination of the hysteresis loops of the load stretch diagrams It was not intended to convey the idea that all degrees of wing-covering looseness were equally desirable, and in the absence of exact data on the effect of fabric looseness on lift and drift, the allowable lack of recoverable stretch must be left to the judgment of the investigator

The effect of the amplitude of the vibrations of a wing covering is, after a few flights, determined by the recoverable stretch of the material, and here again this phase of the investigation is not complete and the magnitude of this property must be left to the judgment of the investigator.

Tear Resistance, Tensibility Method This method of determining tear resistance has been considered less applicable to wing-covering materials, as the value of the load-stretch relations is not fully realized, and has been superseded by the bursting-tear method. The method may be used, however, in cases where the samples are too small for bursting tear and where such apparatus is not readily obtainable.

Resistance to Uniformly Distributed Pressure. As has been already pointed out, the stresses in an airplane-covering material are a function of the curvature of the material at any pressure It has been observed that the tensibility curve obtained by plotting calculated surface tension against stretch of the material during the application of pressure does not agree with the load stretch diagram. The difference is probably due to the initial stress in the doped fabric and to the fact that the end and side effects of the tension strips are not present in the pressure test.

The test does not include the effect of tensions such as would result from wing deflections, but does serve as a more valuable index to factors of safety than the conventional tensile test.

From the pressure-deflection curves it is easier to visualize the relative effect of wing deflection The true conditions of flight are not duplicated, but the effects of the two systems of yarns are integrated and the results are less deceptive than those obtained from tensile tests.

Bursting-Tear Test This test, like the bursting test, is a much better index to relative factors of safety than tension-tear tests. Questions of fabric reinforcement and balance of fabric are readily solved by a careful interpretation of the results obtained from such a test.

Fig 8 represents the load-stretch diagram of a 3/80's unmercerized fabric doped. Both the warp and filling show a dope yield point between 5 and 10 kg, as is represented by the reversal of the curvature of the diagram.

The same construction of fabric made of mercerized yarn is represented by the load-stretch diagram, Fig 9 The filling diagram does not show a reversal of curvature and the elastic limit of the dope will not be exceeded under normal conditions of flight Service tests on these latter two fabrics showed that the unmercerized fabric became somewhat mushy after a short period while the mercerized-yarn fabric stood up very well Similar tests on fabrics of various load-stretch diagrams showed that the fabrics whose dope-filling load-stretch diagrams were practically straight lines stood up exceptionally well.

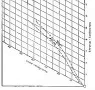

FIG. 8. LOAD-STRETCH DIAGRAM OF A 3/80's UNMERCERIZED FABRIC DOPED

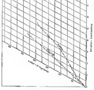

FIG 9. LOAD-STRETCH DIAGRAM OF A 3/80's MERCERIZED YARN

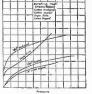

FIG 10. DEFLECTION OF CENTER POINT OF FABRIC WHEN SUBJECTED TO AIR PRESSURE

Results of Tests

It is proposed to give typical examples of tests performed on satisfactory and unsatisfactory fabrics in order that the value of the tests may be more readily realized

Length of Yarn and Crimp A typical set of crimp or yarn-length readings is shown in Fig 4 It will be noted that the load-stretch relations follow a straight-line ratio after a particular tension is reached It is assumed that the yarn has adjusted itself after this point is reached, and that if it were not crimped the relations would exist below this point

Fig 5 shows the crimp of an unwoven yarn of coarse and multiple structure. Consequently the yarn and fibers are in more or less of a crimped condition, as is shown by the lower part of the curve.

Tensibility Properties The load-stretch relations of a standard English Grade A airplane linen are shown in Fig 6. It will be noted that the doped-filling curve is practically a straight line. The doped warp curve shows a distinct yield point, as is indicated by the reversal of the curvature of the diagram.

Fig 7 represents the load-stretch relations of a standard A grade cotton fabric, which curve, it will be observed, is very similar to that of the linen fabric

The load stretch diagram of a fabric may be divided into three parts according to the preponderating influences in these particular portions: (a) crimp, (b) crimp and yarn, (c) crimped yarn characteristics Referring to the warp load-stretch diagram of the cotton fabrics, Fig 7, the part of the curve extending to approximately 3 kg is influenced almost entirely by crimp, the curve from 3 to 10 kg by yarn and crimp, the curve from this point on shows the characteristics of the yarn in its crimped condition

This analysis suggests the particular part of the manufacturing process which should be varied to produce the desired shape of curve The part of the curve below 10 kg may be varied by changing the weave structure, stiffness of the yarn, and more particularly tension, on the yarns during weaving The sum of the respective stretches of the warp and filling at this point is determined by the weave structure, and the relative magnitudes of the respective stretches of the warp and filling are determined by loom tensions

The maintenance of the strength and the tautness of the cotton fabrics is dependent upon the completeness with which the dope protects the fabric and the completeness with which the dope is protected from deteriorating influences such as light and weather

The dope penetration of the 3/80's fabric, 70 square, plain weave, is excessive. The dope penetration of the 2/60's standard fabric is slightly more than that of the standard linen fabric. Excessive penetration of the dope reduces the tear resistance materially If the standard 2/60's fabric is woven in a 2 x 2 basket, the dope penetration is such as to cause an extremely low tear resistance. The small crimp in such a fabric makes it dope up very tightly

Bursting Test. The curves, Fig 10, represent the pressure-deflection properties of the center point of the fabric when subjected to air pressure, as previously described The deflection at any load of the fabric undoped is larger than that of the dope film The deflection of the doped fabric is less than the deflection of either the fabric or the film. This further substantiates the theory that tautness is produced by the dope constraining the yarns in their crimped condition, and that in the standard fabrics the elastic limit of the dope is not exceeded. It will be observed that the cotton fabric is capable of resisting more pressure than the linen, and it will have, therefore, a higher factor of safety. The fabric tautness is practically the same as that of the linen

Tear Resistance. From an examination of the distortion of the lines about a tear, it is concluded that the tear resistance is a function of the strength of the individual yarns and the number being stressed The number of yarns being stressed is dependent upon the load-stretch relations of the fabric and the weave structure To illustrate the effect of doping and weave structure on the tear resistance, let us consider two fabrics: (a) Standard 2/60's mercerized, 80 square, plain weave, (b) 2/60's mercerized yarn, 80 square,

2 x 2 basket. The tear resistance of the 2 x 2 basket is greater than the plain-weave fabric in the undoped condition

The tear-resistance of the 2 x 2 basket is less than the plain-weave fabric in the doped condition The addition of plastics to the dope or the prevention of extreme dope penetration in the 2 x 2 basket will increase its tear resistance very materially The reasons for these differences in tear resistance may be readily conceived from a consideration of the foregoing discussion

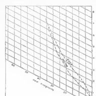

FIG 11 LOAD-STRETCH DIAGRAM OF UNDOPED SILK FABRIC

Silk The strength per unit weight of the silk fabrics has suggested an interesting study of its adaptability to airplane wing coverings Fig 11 represents the load-stretch diagram of an undoped silk fabric made from a Chinese steam filature silk and is representative of all silk fabrics made from what may be termed line silk. The curve shows a radical yield point and excessive stretch, and therefore is not a logical airplane-wing covering material It also indicates extremely inelastic properties, which hysteresis determinations substantiate.

The silk schappe fabrics do not indicate a yield point, but do in most cases have excessive stretch They would, however, make very good wing coverings Doped silk fabrics are caused to become loose upon exposure to damp weather, and in many cases a rot develops on the inside of the yarn Both of these objectionable features will probably be overcome in the near future

Further experiments are being conducted to determine the properties of airplane fabrics which have to do with the calculation of the exact performance of any fabric under any assumed condition of flight, which will include the effects of various rib spacings, wing deflections, vibrations, and the effects of various fabric structures.

Personnel of the American Air Services

Personnel of the Army Air Service

In the report of the Secretary of War that has just been made public, the following interesting statistics are given regarding the personnel of the Air Service from April, 1917, to May, 1919.

Personnel Data from the Report of the Chief Signal Officer Follows

	1917								1918					
	April	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Total
Nonflyers			137	71	444	530	1,124	701	856	1 454	1 145	54	1,640	8,148
Trained flyers	1	94	36	—2	74	330	327	133	663	434	2 206	1 652	1 737	7 938
Total officers	32	84	166	69	518	860	1 451	1 034	1,519	1 888	1 351	1 706	3 377	16 064
Cadets				1,104	582	828	646	785	470	504	1 032	—70	—534	5 133
Enlisted men	1 160	10	8 997	9,481	518	1 891	14 167	51 131	4 875	17 672	19 197	4 378	5 832	144,779
Civilian employees	310	414	239	473	655	748	663	852	879	972	1 349	1 471	920	9,960
Plane and engine contractors employees		7,298	667	926	2 121	1 622	7 234	3 234	8 609	6 272	3 554	[illegible]	8 047	56,[illegible]
Examining boards[1]		8	4		5	3	2	20	18	—17	—5	—10	—5	35
Ground schools		8											—1	7
Flying schools	1	2	1	1			1	5					1	23
Balloon schools	1					1		1				2		5
Photographic schools							1							4
Schools for mechanics							6	1	8	11	2	—11		15
Hours flown					41 861	9,707	8 808	11 065	21 891	36 807	7 212	81 138	98 338	146 [illegible]
Flying deaths (United States)		4		4	1	2	4	8	10	21	20	18	20	13[illegible]

[1] Includes about 13 per cent of Signal Corps proper

[2] Approximate

NOTE—Squadrons trained, equipped, and in fighting from June 1918 8, July 1918 40, August 1918 52, September 1918 55

Report of the Secretary of the Navy

In the annual report of the Secretary of the Navy, which has just been made available, the following information regarding Naval fliers is given

Of gratifying proportions and effectiveness have been the expansion of aviation in the Navy.

On July 1, 1917, naval aviation was still in its infancy At that time there were only 45 naval aviators There were officers of the Navy, Marine Corps, and Coast Guard who had been given special training in and were attached to aviation. There were approximately 200 student officers under training and about 1250 enlisted men attached to the Aviation Service. These enlisted men were assigned to the three naval air stations in the country which were then in commission Pensacola, Fla., had about 1000 men, Bay Shore, Long Island, N. Y., which was put into operation at that time, had about 100 men, and Squantum, Mass., which was abandoned in the fall of 1917, had about 150 men

On July 1, 1918, there were 823 naval aviators, approximately 2052 student officers, and 400 ground officers attached to naval aviation In addition, there were over 7300 trained mechanics and over 5400 mechanics in training The total enlisted and commissioned personnel at this time was about 30,000

Of untold importance during the year was the establishment and placement under operation of naval air stations at all the strategic and important points on the coast of the United States Likewise, a station was established in the Canal Zone As a result of those activities, the larger part of the American coast has been constantly patroled by naval aircraft Furthermore, the Navy Department has already planned and is fully prepared to establish enough additional stations to so complete the system that every foot of the coast of the United States can be thoroughly and constantly patroled. Many of the stations now in operation are equipped not only with seaplanes but also with dirigibles and kite balloons. The extent of activities that are being carried on can be readily illustrated Thus, during June, 1918, a total of 25,642 flights, covering about 2,155,860 miles, were made by seaplanes at stations along the United States coast. These figures include both patrol and training. During that same period of time lighter-than-air craft made a total of 613 flights, covering about 56,420 miles

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News of the Fortnight

$390,000,000 Asked for Aircraft

Departmental estimates presented to Congress include $165,000,000 for Army and $225,000,000 for Navy aviation activities for the next fiscal year beginning July 1, 1919

The most striking equipment appropriation of the Army budget is for the air service. Under aircraft production a lump sum estimate of approximately $145,000,000 is submitted, supplemented by an additional $20,000,000 for the air service itself Last year the appropriations under these two headings were respectively $780,000,000 and $184,000,000 Even with the great cut made because of the end of hostilities, the total of $165,000,000 now sought, however, shows that great stress is to be laid hereafter on aircraft development

Of the air service estimates, $11,400,000 is set aside for aviation equipment and $5,235,000 for maintenance of plants and stations and establishment of new ones The production estimate is not shown in detail. An attached table, however, gives the following information on expenditures this year: Of a total outlay of $215,000,000 on material $18,488,000 went for airplanes and parts another $77,000,000 for airplane engines, and approximately $2 000,000 for balloons.

Under fortifications a total of $574,237,000 is asked, against $3,099,799,000 this year This estimate, however, carries much of the army artillery and ammunition expenditures in addition to strictly fortification outlays The artillery item of the fortifications estimate is $542,145,000, against $2,795,000,000 this year A new appropriation of $31,684,000 is asked for aerial seacoast defenses

The Navy estimates provide an item of $225,000,000 for aviation, a slight increase over this year They duplicate last year's $2 665,000 for training camps and other recruit and naval reserve instruction

Plans for the coastal air patrol, including the purchase of four airships of the Zeppelin type, a dozen dirigibles and twelve dozen smaller balloons, as well as fighting airplanes, were related to the House Naval Affairs Committee Nov 27 Navy officers said that $90,000 000 of the $220,000 000 appropriated for naval aviation would be returned to the Treasury next July at the close of the fiscal year

The Navy Department, which has the coast patrol in charge, proposes to pay $1,500,000 each for the Zeppelins, which are regarded by Rear Admiral Taylor and Captain Steele, who are in charge of coast patrol, as being impressive in their work and particularly adapted to scout duty Admiral Taylor said that during the war a Zeppelin flew from Germany to German East Africa to bring home a German commander who was stationed in the colony However, the trip proved of no avail as the British had already captured the commander

Twelve dirigibles will cost $250,000 each and the smaller workable balloons will cost $75,000 each Also, for the 1920 plans, the Navy Department will buy 108 fighting escort planes

Coastal defense is eagerly urged by the Navy Department The officers testified that if the patrol had been completely organized last year the U-boats which menaced American shores would have been put to flight

Twenty-one stations are contemplated, some of which have been built, and others are under construction There will be stations commanding the Gulf, Pacific and Atlantic coasts and in the insular possessions One will be installed on the Maine coast, somewhere between Portland and Rockland. Others will be placed at Narragansett Bay New York Harbor, Port Arthur Tex , San Francisco, Seward, Alaska two in Hawaii, Guam, St Thomas (West Indies) and the Panama Canal Zone Stations are under construction at Camp Lookout, Moorehead, N. C., Brunswick, Ga , and Galveston, Tex , while stations have been completed at Chatham, Mass Rockaway Beach N Y , Cape May, Miami, Fla , Key West, San Diego, Cal , and another also in California

The officers said that a non-inflammable gas for balloons had been discovered, which was so efficient that it could be fired into, through the gas bag, without catching fire. The gas was said to cost a little more than hydrogen, but it was also said to leak less rapidly, and the officers thought the cost would be about the same Admiral Taylor said that experiments would be continued with the Kirkham triplane, which has made 180 miles an hour in trials.

Machines for the Aerial Mail

Operation of the new main trunk air mail lines will be directly under the supervision of the Post Office Department, and the machines will be flown by civilian aviators or released Army pilots. Feeder lines running in every direction from the main lines will be operated by the Air Service and the machines will be piloted by Army flyers. It is also known that the present intention of the Post Office Department is not to attempt an exclusively air line from New York to San Francisco Instead the air mail will be delivered at Denver and from there carried by train across the Rockies, to be picked up by airplane again at some point to be selected west of the Rockies. It was pointed out that air mail leaving New York would catch at Denver the regular transcontinental mail which left New York twenty four hours ahead of the air mail.

Arrangements have been concluded for the Army to turn over to the Post Office Department 100 D H-4 Liberty machines for use in immediately extending the airplane mail service. These machines will enable the Post Office Department to extend its trunk lines, while the cooperation of the Air Service will insure the early operation of numerous feeder lines

Twelve 100-foot wing spread Handley Page twin Liberty machines and 12 Glenn L Martin 70-foot wing spread twin Liberty machines are to be the first large weight carrying machines to be placed in the Air Mail Service Engines and all parts for the former are now being assembled. One completed machine, built by the Standard Aircraft Corporation of Elizabeth, N J , is ready for its first mail flight. It is understood the other Handley Pages will be assembled at the Standard factory from parts fabricated on orders for 500 of these planes which were being shipped to the American Overseas forces

Ever since the projected air mail route between New York and Chicago was announced by the Post Office Department, doubt has been expressed in various quarters as to the practicability and safety of the air line through the mountainous region of Pennsylvania This involves a stretch of rough and wooded mountains of about 60 miles between Bellefonte, Lehighton and Clarion, Pa

Through the active cooperation of the Manufacturers' Aircraft Association with the Air Mail Service, a survey of this region has been undertaken by the Association looking to locating and securing title to six tracts of land which will be put in shape for landing stations. This work is being done directly by the Association and at its expense

The location of these fields, it is expected, will provide an emergency landing every 10 miles for not only the mail planes, but for regular commercial air lines between the Eastern cities and Cleveland, Detroit, Chicago

It is expected that the first extension of the new service will be from New England to the Far South. The coast-to-coast route is expected to be taken up next Not less than fifty aerial mail lines, with the employment of at least 1000 military aviators, will probably be established within a few weeks.

The Chicago-New York air mail service is to be started on Dec 15 A Handley Page machine is to be used for carrying the mail from this end The Elizabeth terminus on the field of the Standard Aircraft Corp will be used, and mail arriving there will be transferred to New York City by special train This field is now the New York terminus of the Washington service

Pardons for Cols. Mixter and Vincent

President Wilson just before he sailed for France authorized the announcement that he had pardoned Lieut. Cols. George W Mixter and J G Vincent, whom the recent report submitted by Charles E Hughes, after his investigation of aircraft production, declared to be guilty of violation of a section of the criminal code which prohibits any person interested in profits or contracts of a corporation from acting as an officer or agent of the Government for the transaction of business with that corporation

Liberty Fuel Cheaper Than Gasoline

Major O. B. Zimmerman, Director of the War Department's research and development division, has given out some fact about "Liberty" fuel, discovered by army engineers and described as vastly cheaper than gasoline and having more power.

The new fuel oil, which will soon be on the market, was discovered after five months of experimentation by army officials on the qualities of gasoline for motor power. Its base is kerosene, with other ingredients of a low cost, and produced in quantity in this country. The process of manufacture is exceedingly simple, and the fuel can be used in all kinds of motor-driven vehicles.

Major Zimmerman, who with Capt. E. C. Weisgerber, of the gas and oil production division of the War Department, is credited with the new discovery, summarized its advantages as follows:

It will start easier than gasoline.

Leaves no residue of carbon, soot, etc.

Explodes at temperatures below zero.

Is capable of greater mileage per gallon than gasoline.

Safe against premature explosion, igniting only from spark or flame.

Its combustion requires less oxygen than gasoline.

Can be manufactured for less money than gasoline.

It can be used in automobiles without any change in the carburetor and without detriment to the car.

Developed in connection with the Liberty engine, it has shown itself superior to gasoline as an airplane fuel. It has 17 per cent higher fuel economy than export gasoline.

One of the Bureau of Standards' reports showed that a three-ton truck ran 286 miles, averaging six and one-third miles to a gallon of gasoline, 63.5 miles a quart for lubrication oil and eight and a half gallons of water. With Liberty fuel the truck averaged 10.4 miles on a gallon of fuel, 103.1 miles a quart of lubricating oil and two gallons of water.

Loening's Monoplane a Success

Major-Gen. William L. Kenly, Director of Military Aeronautics, has announced the receipt of information from Dayton, Ohio, that the Loening two-seater monoplane in recent tests there developed 145 m. p. h., with full military load, including four guns, which is in excess of any record made by a European single-seater combat machine. The Loening plane in these tests also climbed 25,000 ft., carrying two passengers.

This machine is equipped with a 300 hp. American Hispano engine built by the Wright-Martin Corp.

The design of the machine is entirely original and a distinct American development which has finally been declared by experts to be one of the most advanced designs yet brought out. The simplification of the machine for the purpose of production is such that it requires one-tenth the number of parts of the ordinary European design. All wire stays have been eliminated and the monoplane type of structure for the first time rendered as strong and rigid as any biplane without losing any of the well-known advantages of the monoplane.

To Encourage Trans-Atlantic Flight

To encourage a trans-Atlantic flight by an American designed and built airplane, Inglis M. Uppercu, president of the Aeromarine Plane and Motor Corporation, has authorized Chas. F. Willard, his chief engineer, to announce the company's willingness to undertake the design and construction of a machine capable of accomplishing this flight for any individual, organization or company, at actual cost of material and labor only. Mr. Uppercu, who has always been prominent in promoting bicycle, automobile and flying events, believes that unless active steps are taken at once in this country, an English, French, Italian or even German airplane will be first to cross the Atlantic. This view is understood to be based on first hand knowledge obtained by Mr. Willard during his recent trip to Europe as a member of an American aeronautic commission sent over by this Government.

Test Trip of the Christmas Plane

A new airplane, the invention of Dr. William W. Christmas of Washington, D. C., was tried out at Central Park on the east end of Hempstead Plains December 6.

C. F. Kettering's Dinner Engagement

Calling up New York City from Dayton, Ohio, at 10 o'clock in the morning, making an engagement for dinner and the theatre in the metropolis for that evening and keeping it, was the exploit November 30th of C. F. Kettering, vice-president of the Dayton-Wright Airplane Co. and president of the Society of Automotive Engineers, and Howard M. Rinehart, chief pilot of that company. The next day they came to Washington in proportionately the same time.

Breaking of all non-stop airplane flight records in the United States was necessary in order that they arrive on time.

The trip was made in a De Haviland-4 army 'plane equipped with a 12-cylinder, 400-hp. Liberty engine.

From the time the big two-seater arose from the experimental field south of the plant in Dayton until it was parked in one of the hangars at the Mineola flying field, near New York, just four hours and ten minutes elapsed. The distance from Dayton to New York is 550 miles. Slightly more than 134 miles an hour was the average for the trip.

Fifty Passengers on the NC-1

It is announced from Washington that an NC-1 plane of the United States Navy broke the world's record for passenger-carrying capacity at the Naval Air Station, Rockaway, N. Y., on November 27, when a flight was made with fifty men on board. The flight was for the special purpose of demonstrating the plane's lifting capacity. Lieut. David H. McCullough, U. S. N. R. F. C., was the pilot.

The NC-1 is the first American flying boat with three Liberty engines, which develop a maximum of 1200 hp., and give a cruising speed of about 80 m. p. h.

The design and the construction of the NC-1, with its triple engines, huge size and other distinctive features, was carried out by the Navy in cooperation with the Curtiss Engineering Corp.

The NC-1 made her trip from Rockaway to Washington, about 350 miles, in 5 hours and 20 minutes.

Changes in the Dept. of M. A.

Col. Arthur Woods has been appointed Assistant Director of Military Aeronautics. Colonel Woods, who was Chief of the Personnel Section, Division of Military Aeronautics, is the immediate successor of Col. Gerald C. Brant. The appointment of Colonel Brant, however, was only temporary, and therefore, according to the records of the Division, Colonel Woods is officially the successor of Col. Henry H. Arnold.

Colonel Brant has been appointed chairman of a Board to work out and recommend plans for the permanent organization of the air forces.

Colonel Woods has been succeeded as Chief of the Personnel Section by Lieut.-Col. Rush B. Lincoln, formerly Executive Officer of that section.

Glenn Martin Bomber's Flight

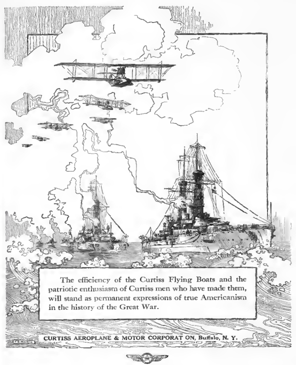
A big Glenn Martin daybombing plane, which left Cleveland, Ohio, on December 5, on its 430-mile trip to Washington, arrived at 12.25 the next day at Bolling Field, having been delayed over night at Avonmore near Pittsburg, Pa., by a snow storm. The last leg of the flight—175 miles, from near Pittsburg to Washington—was made in one hour and fifteen minutes, which included a climb through snow clouds to an elevation of 12,000 ft.

Major Harley W. Lake, pilot, who acted as observer and inspector for the Division of Military Aeronautics, states that this is the fastest flight ever made by a machine of this type.

No Licenses for Civilians Now

Inquiry at the War and Navy departments brings out the fact that civilian flying licenses are restricted to the Red Cross and manufacturers' test pilots for the Army and Navy.

It is unlikely that there will be any modification of the order for some time to come.



The Air Transport Number
of
Aviation and Aeronautical Engineering

January 1, 1919

will present:

All available information bearing upon the policy of the United States for its permanent military aeronautical establishment and the plans of the Post Office Department, Reclamation and Forestry Services, Coast Patrol and Geodetic Survey, etc.

Plans of the manufacturers for creating a commercial demand.

Special articles which will contain a fund of information and suggestions as to possible markets for American aircraft in the United States and abroad, and how to reach those markets. Views of the leading men of the industry, of Government officials, army and navy officers, as well as representative opinions from possible purchasers of aircraft for sporting and utilitarian purposes.

The question of direct Government subsidies for commercial aircraft lines will be ably discussed.

The latest American and foreign planes designed for or adaptable to commercial purposes will be illustrated and described.

Progress at home and abroad in diverting surplus military aircraft to peaceful pursuits and the agencies working to this end.

The solid and authoritative material in this special issue will present the true status of the American aircraft art and be a guide for Congress in considering appropriations for aeronautics and cooperating agencies in properly presenting this subject to the public.

The January 1st Issue will close December 26th

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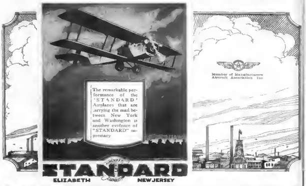

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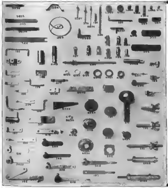

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Aeronautical Trade Directory

AVIATION AND AERONAUTICAL ENGINEERING will furnish information and addresses of companies listed below.
Names of Advertisers in this issue are printed in capitals.
See Index to Advertisers on page 640

ACCESSORIES AND INSTRUMENTS

Advance Felt Specialty & Cutting Co.
International Aeronautical Instrument Corp
Johns-Manville H. W. Co
Ring, Julius, Optical Co
The Moto Meter Co
National Gauge & Equipment Co.
Nelson Blower & Furnace Co
O'Hara Waltham Dial Co.
Queen Gray Co.
Rieker, Walter
Sperry Gyroscope Co
Standard Aeronautical Co
Stewart-Warner Speedometer Corp.
TAYLOR INSTRUMENT COMPANIES
VEEDER MFG. CO
Western Electric Co.

AIRPLANES

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Blackhawk Airplane Co
Blanchard-Radley Aircraft Co
Boeing Airplane Co
Breese Aircraft Corp
THE BURGESS COMPANY
Continental Aircraft Corp.
CURTISS AEROPLANE & MOTOR CORP
CURTISS ENGINEERING CORP
DAYTON-WRIGHT AIRPLANE CO.
Des Lauriers Aircraft Corp.
Dewey Aeroplane Co.
Engel Aircraft Co.
Fisher Body Corp.
Fowler Airplane Corp.
Gallaudet Aircraft Corp
Lanzius Aircraft Co
Lawrence-Lewis Aeroplane Co.
Lawson Aircraft Corp.
Lewis & Vought Corp
Liberty Iron Works
Loening Aeronautical Eng. Corp
Longren Aeroplane Co
L. W. F. ENGINEERING CO
Martin Aeroplane Factory
MARTIN, GLENN L. CO.
Michigan Aircraft Corp
Ordnance Eng'ring Corp.
Patterson Aeroplane Co
Peirce, Sam'l S., Aeroplane Corp
RUBAY CO
St. Louis Aircraft Co.
Smith, Kyle, Aircraft Co.
Sperry, Lawrence, Aircraft Co
Springfield Airplane Co
STANDARD AIRCRAFT CORP
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THOMAS-MORSE AIRCRAFT CORP
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WITTEMANN-LEWIS AIRCRAFT CO
Whittemore-Hamm Co.
WRIGHT MARTIN AIRCRAFT CORP

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Detroit Gas Turbine Corp.
DUESENBERG MOTOR CORP
General Ordnance Co.
General Vehicle Co.
Gyro Motor Co
HALL-SCOTT MOTOR CAR CO
Kemp Machine Works
Hessler Motor Co
Nordyke & Marmon.
Packard Motor Co.
Roberts Motor Mfg. Co.
Rolls-Royce, Ltd.
Sterling Engine Co.
Sturtevant, B. F., Co.
Trego Motors Corp.
THOMAS-MORSE AIRCRAFT CORP.
UNION GAS ENGINE CO.
Van Blerck Motor Co.
Willys-Overland Co.
WISCONSIN MOTOR MFG. CO.
Warldn Motor Co.
WRIGHT MARTIN AIRCRAFT CORP

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Chicago Aeronautical Supply Co.
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General Aluminum & Brass Mfg. Co.
GENERAL BAKELITE CO
Holbrook Co
Kawneer Mfg Co
KING SEWING MACHINE CO.
Levett, Walker M., Co.
New Jersey Veneer Co.
Pressed & Welded Steel Products Co.
Rogers Construction Co
Standard Parts Co
Welch Mfg Co
Whittemore-Hamm Co.
Widman, J. C., & Co
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ALUMINUM CO. OF AMERICA
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Levett, Walker M., Co.
Laygrand & Co.
McAdamite Aluminum Co.
SO-LUMINUM MFG & ENG CO (SOLDER)
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United Smelting & Aluminum Co.

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Michigan State Auto School
Morris, Bud, Airplane School
Penn. State School of Aero-Mechanics
West Side Y. M. C. A.
Whittemore-Hamm Co.

(Continued on page 683)

Aeronautical Trade Directory—*Continued*

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THE FAFNIR BEARING CO.
Gurney Ball Bearing Co
HESS-BRIGHT MFG CO
NEW DEPARTURE MFG CO
NORMA COMPANY OF AMERICA
S. K. F. BALL BEARING CO
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Connecticut Aircraft Co.
Custer Specialty Co. (Statoscope)
Gas Engineering Co. (Gas Plants)
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Sussfeld & Lorch
TAYLOR INSTRUMENT COMPANIES

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Magnolia Metal Co.

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Baeder & Adamson
CERTUS COLD GLUE CO
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Witman, J. C., Co

(*Continued on page 661*)

Aeronautical Trade Directory—*Continued*

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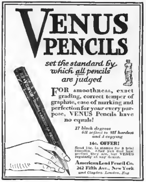
(Continued on page 643)



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Service Motor Truck Co
White Company, The

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National Wire Wheel Works
Sprenger Wire Wheel Corp.
Watson Wheel & Rim Corp.
Wire Wheel Corporation of America

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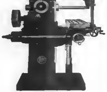

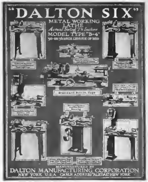

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